PATENT

Atty Docket No.: 10005732-1
App. Ser. No.: 09/882, 038

IN THE CLAIMS:

Please find a listing of the claims below. The statuses of the claims are shown in parentheses.

1. (Canceled).

2. (Currently amended) ~~The method of claim 1,~~ A method for gamut mapping of an input image using a space varying algorithm, comprising:

receiving the input image;

converting the color representations of an image pixel set to produce a corresponding electrical values set;

applying the space varying algorithm to the electrical values set to produce a color-mapped value set;

reconverting the color-mapped value set to an output image; and

wherein the space varying algorithm minimizes ~~a~~ the following variational problem ~~represented by~~:

$E(u) = \int_{\Omega}(D^2 + \alpha|\nabla D|^2)d\Omega$, subject to $u \in \vartheta$, wherein Ω is a support of the input image, ϑ is the target gamut, α is a non-negative real number, $D=g*(u-u_0)$, g is a normalized Gaussian kernel with zero mean and a small variance σ, u_0 is the input image, and u is the output image.

3. (Original) The method of claim 2, further comprising:

solving the variational problem at a high value of α;

solving the variational problem at a low value of α; and

averaging the solutions.

4. (Original) The method of claim 3, wherein the step of averaging the solutions comprises using a spatially adaptive weighting scheme, comprising:

$u_{final}[k,j] = w[k,j]u_{small}[k,j](1\text{-}w[k,j])u_{high}[k,j]$,

wherein the weight $w[k,j]$, comprises:

$$w[k,j] = \frac{1}{1 + \beta|\nabla g * u_0|^2}, \text{ and}$$

wherein β is a non-negative real number.

5. (Original) The method of claim 2, wherein the variational problem is solved according to:

$$\frac{du}{dt} = \alpha g * \Delta D - g * D, \text{ subject to } u \in \vartheta.$$

6. (Original) The method claim 2, wherein the space varying algorithm is solved according to:

$$u_{ij}^{n+1} = u_{ij}^n + \tau(\alpha L_{ij}^n - \overline{D_{ij}^n}), \text{ subject to } u_{ij}^n \in \vartheta, \text{ wherein}$$

$\tau = dt$,

$D^n = g * g * (u^n - u_0)$

$L^n = D_2 * (u^n - u_0)$ and

$D_2 = g_x * g_x + g_y * g_y$

7. (Currently amended) ~~The method of claim 1,~~ A method for gamut mapping of an input image using a space varying algorithm, comprising:

receiving the input image;

converting the color representations of an image pixel set to produce a corresponding electrical values set;

applying the space varying algorithm to the electrical values set to produce a color-mapped value set;

reconverting the color-mapped value set to an output image; and

wherein the space varying algorithm minimizes ~~a~~ the following variational problem ~~represented by~~:

$E(u) = \int_{\Omega} (\rho_1(D) + \alpha\rho_2(|\nabla D|))d\Omega$, subject to $u \in \vartheta$, wherein ρ_1 and ρ_2 are scalar functions, Ω is a support of the image, ϑ is the target gamut, α is a non-negative real number, $D=g*(u-u_0)$, g is a normalized Gaussian kernel with zero mean and a small variance σ, u_0 is the input image, and u is the output image.

8. (Original) The method of claim 2, further comprising:

decimating the input image to create one or more resolution layers, wherein the one or more resolution layers comprises an image pyramid; and

solving the variational problem for each of the one or more resolution layers.

9. (Currently amended) The method of claim [[1]]2, wherein the method is executed in at least one of a camera and a printer.

10. (Currently amended) The method of claim [[1]]7, wherein the method is executed in at least one of a camera and a printer.

11. (Canceled).

12. (Canceled).

13. (Original) ~~The computer-readable memory of claim 12,~~ A computer-readable memory for color gamut mapping, comprising an instruction set for executing color gamut mapping steps, the steps, comprising:

converting first colorimetric values of an original image to second colorimetric values, wherein output values are constrained within a gamut of the output device; using a space varying algorithm that solves an image difference problem; and

optimizing a solution to the image difference problem, wherein the image difference problem is represented by:

$$E(u) = \int_{\Omega} (D^2 + \alpha |\nabla D|^2) d\Omega$$

subject to u $u \in \vartheta$, wherein Ω is a support of an input image, α is a non-negative real number, ϑ is the target gamut, $D=g*(u-u_0)$, g is a normalized Gaussian kernel with zero mean and small variance σ, u_0 is the input image, and u is an output image.

14. (Currently amended) The computer-readable memory of claim [[12]]13, wherein the instruction set further comprises steps for:

solving the image difference problem at a high value of α;

solving the image difference problem at a low value of α; and

averaging the solutions.

15. (Original) The computer-readable memory of claim 14, wherein averaging the solutions comprises using a spatially adaptive weighting scheme, comprising:

$u_{final}[k,j] = w[k,j]u_{small}[k,j](1\text{-}w[k,j])u_{high}[k,j]$,

wherein the weight $w[k,j]$, comprises:

$$w[k,j] = \frac{1}{1 + \beta|\nabla g * u_0|^2}, \text{ and}$$

wherein β is a non-negative real number.

16. (Currently amended) ~~The computer-readable memory of claim 12,~~ A computer-readable memory for color gamut mapping, comprising an instruction set for executing color gamut mapping steps, the steps, comprising:

converting first colorimetric values of an original image to second colorimetric values, wherein output values are constrained within a gamut of the output device; using a space varying algorithm that solves an image difference problem; and

optimizing a solution to the image difference problem, wherein the image difference problem is represented by:

$$E(u) = \int_{\Omega} (\rho_1(D) + \alpha\rho_2(|\nabla D|))d\Omega, \text{ wherein } \rho_1 \text{ and } \rho_2 \text{ are scalar functions.}$$

17. (Currently amended) ~~The computer readable memory of claim 12,~~ A computer-readable memory for color gamut mapping, comprising an instruction set for executing color gamut mapping steps, the steps, comprising:

converting first colorimetric values of an original image to second colorimetric values, wherein output values are constrained within a gamut of the output device; using a space varying algorithm that solves an image difference problem; and

optimizing a solution to the image difference problem, wherein the instruction set further comprises steps for:

decimating the input image to create one or more resolution layers, wherein the one or more resolution layers comprise an image pyramid; and

solving the image difference problem for each of the one or more resolution layers.

18. (Original) The computer-readable memory of claim 17, wherein the instruction set further comprises steps for:

(a) initializing a first resolution layer;

(b) calculating a gradient G for the resolution layer, the gradient G comprising:

$G = \Delta(u - u_0) + \alpha_K(u - u_0)$, wherein Δx is a convolution of each color plane of x with

$$K_{LAP} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -2 & 1 \\ 0 & 1 & 0 \end{bmatrix} \text{ and } \alpha_k = \alpha_0 * 2^{2(k-1)};$$

(c) calculating a normalized steepest descent value $L_j = L_{j-1} - \mu_0 * \mu_{NSD} * G$, wherein μ_0 is a constant;

(d) projecting the value onto constraints $Proj_{\vartheta}(L_j)$, wherein $Proj_{\vartheta}(x)$ is a projection of x into a gamut ϑ; and

(e) for a subsequent resolution layer, repeating steps (b) – (d).

19. (Original) A method for image enhancement using gamut mapping, comprising:

receiving a input image;

from the input image, constructing an image pyramid having a plurality of resolution layers;

processing each resolution layer, wherein the processing includes completing a gradient iteration, by:

calculating a gradient G;

completing a gradient descent iteration; and

projecting the completed gradient descent iteration onto constraints; and

computing an output image using the processed resolution layers.

20. (Original) The method of claim 19, wherein the gradient G, comprises:

$$G = \Delta(u\text{-}u_0)\ \alpha_k(u\text{-}u_0),$$

wherein u is the output image, u_0 is the input image, and α is a non-negative real number.

21. (Original) The method of claim 19, wherein completing the gradient descent iteration comprises calculating:

$$\mu_{NSD} = \Sigma G^2 / (\Sigma(G * \Delta G) + \alpha_k \Sigma G^2) \text{ ; and}$$

$$L_j = L_{j-1} - \mu_0 \cdot \mu_{NSD} \cdot G,$$

wherein μ_{NSD} is a normalized steepest descent parameter, μ_0 is a constant, k is a number of resolution layers in the image pyramid, and j is a specific resolution layer.

22. (Original) The method of claim 19, wherein projecting the completed gradient descent iteration onto the constraints is given by:

$L_j = Proj_a(L_j)$,

wherein $Proj_a(x)$ is a projection of x into a gamut ϑ.

23. (Original) The method of claim 19, wherein constructing the image pyramid, comprises:

smoothing the input image with a Gaussian kernel;

decimating the input image; and

setting initial conductive L_0 = max {Sp}, wherein Sp is an image with the coarsest resolution layer for the image pyramid.

24. (Original) The method of claim 23, wherein the Gaussian kernel, comprises:

$$K_{PYR} = \begin{bmatrix} \frac{1}{16} & \frac{1}{8} & \frac{1}{16} \\ \frac{1}{8} & \frac{1}{4} & \frac{1}{8} \\ \frac{1}{16} & \frac{1}{8} & \frac{1}{16} \end{bmatrix}$$

25. (Currently amended) The method of claim 19, wherein processing each resolution layer further comprises applying a space varying algorithm to minimize ~~a~~ the following variational problem ~~represented by~~:

$$E(u) = \int_{\Omega} (D^2 + \alpha |\nabla D|^2) d\Omega,$$ subject to $u \in \vartheta$, wherein Ω is a support of the image, ϑ is the target gamut, and $D=g*(u-u_0)$, wherein g is a normalized Gaussian kernel with zero mean and small variance σ, u_0 is the input image, u is the output image, and wherein α is a non-negative real number.

26. (Original) The method of claim 19, wherein processing each resolution layer comprises applying a space varying algorithm to minimize a variational problem represented by:

$$E(u) = \int_{\Omega} (\rho_1(D) + \alpha \rho_2(|\nabla D|)) d\Omega,$$ subject to $u \in \vartheta$, wherein ρ_1 and ρ_2 are scalar function.

27. (Original) The method of claim 26, wherein $\rho 1$ and $\rho 2$ are chosen from the group comprising $\rho(x) = |x|$ and $\rho(x) = \sqrt{1 + x^2}$.